The Effect of Different Water Solution on the Electrical Conductivity of Polyester Reinforced With Waste Aluminum

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Abstract

In this work, we studied the electrical conductivity behavior of waste Al reinforced polyester composite material in different solutions (distilled water, tap water &3.5%NaCl) with a weight fraction (5, 15, 30 &45) was investigated for (6) weeks immersion time. The results exhibited that increasing in electrical conductivity with increasing in immersion time, also Maximum value of electrical conductivity was recorded at immersion in 3.5% NaCl solution. However electrical conductivity increases with increasing in weight fraction of waste aluminum due to opening path of electrons thus electrical conductivity will be increased.

Keyword: waste Al, polyester &electrical conductivity

Introduction

The materials which conduct electricity when an electrical potential difference is applied across them are known as conducting materials. The most important property of a material is the electrical resistance, which characteristics the electrical properties more lucidly. The electrical conductivity (σ) of a material depends on the presence of free electrons or conduction electrons, which move freely in the metal while a material which offers a very large resistance to flow of current is known as insulating material.

All dielectric materials are insulators. The distinction between a dielectric material and an insulator lies in the application to which one is employed. The insulating materials are used to resist the flow of current through it when a difference of potential is applied across its ends. On the other hand, the dielectric materials are used to store electrical energy. A dielectric material is one which stores electrical energy with a minimum dissipation of power, since the electrons are bound to their parent molecules and hence, there is no free charges [1].

One of the largest areas of application for polymers is related to electrically insulating materials. Polymers contain a very low concentration of free charge carriers and thus they are non-conductive and transparent to electromagnetic radiation.

These drawbacks have led to the growth in the research for electrically conductive polymers. A critical concentration of filler beyond which the polymer composite becomes conductive is referred to as the percolation threshold. At this point, a conductive network is formed through the matrix. This permits the movement of charge carriers of the fillers through the matrix and so the composite achieves a certain degree of electrical conductivity [2].

A composite is a heterogeneous substance consisting of two or more materials which do not lose the characteristics of each component. This combination of materials brings about new desirable properties. Composite materials are widely used in many fields of industry. Depending on required properties mechanical and electrical properties of composite materials are important for nearly all applications in industry [3].

The starting material for a thermoset polyester matrix is an unsaturated polyester resin that contains a number of C=C double bonds. The curing reaction for polyester resins is initiated by adding small quantities of a catalyst, such as an organic peroxide or an aliphatic azo compound the catalyst decomposes rapidly into free radicals, which react (mostly) with the styrene molecules and break their C=C bonds. Styrene radicals, in turn, join with the polyester molecules at their unsaturation points and eventually form cross-links between them .The resulting material is a solid polyester resin. Polyester resins have a series of valuable properties suitable viscosity, ability to solidify at both room and high temperatures, high strength and dielectric ratings, high chemical stability and the do not release volatile substances
[3].

P.L. studied the effect of recycled copper on the electrical, mechanical and thermal stability properties of the polyester composites. Electrical conductivity results revealed that increasing in conductivity with increasing in filler loading [4].

N.A. studied the electrical conductivity behavior of Cu-powder reinforced epoxy composite material in different solutions (distilled water, tap water &3.5%NaCl) with a weight fraction (5, 15, 30 &45). The results exhibit that electrical conductivity increases as increasing immersion time due to the specimen was absorbed the solutions [5].

B. H. studied The D.C and A.C electrical conductivity of (poly-methyl methacrylate -

alumina) composite with different percentages(0,15,25,35 and 45) wt.% and different thickness. The experimental results showed that the D.C electrical conductivity increased with increasing the alumina concentrations and temperature. Also the activation energy change with increasing of additional alumina. The dielectric constant, dielectric loss, A.C electrical conductivity are changed with change the concentration of the filler and frequency of applied electrical field [6].

Experimental set up

1. The materials studied were polyester which consisted of its hardener in 3:1 ratio reinforce with Al waste.
2. Weight fraction of Al waste range from 5% up to 45% mixed with measured polyester.
3. The mixture was mould and the samples of polymer composite were cutting with (2&0.5) cm dimensions.
4. The sample surface was Polishing to improve smoothing by using SiC paper then coating the surface of samples by thin film of silver by using coating unit .
5. Figure 1 shows the schematic diagram of measurement apparatus
6. Whole Samples were immersed in distilled water, tap water & water +3.5%NaCl at room temperature for different periods of time (1, 2, 3, 4, 5&6) weeks.
7. The samples were dried at room temperature for two hours after immersion test.

$$\sigma = \frac{d}{R.A} \qquad \text{….. (1)}$$

Where:
σ:electrical conductivity (Scm^{-1})
d: diameter of specimen, cm
R.: electrical resistance, Ω
A: cross- section area, cm^2

Results and Discussion

Electrical conductivity is used to specify the electrical character of a material and is indicative of the ease with which a material is capable of conducting an electric current . Solid materials exhibit an amazing range of electrical conductivities, extending over 27 orders of magnitude; probably no other physical property experiences this breadth of variation. In fact, one way of classifying solid materials is according to the ease with which they conduct an electric current; within this classification scheme there are three groupings: conductors, semiconductors, and insulators.

The dependence of the electrical conductivity of polyester reinforced with waste- Al composites on the waste -Al weight fraction is shown in Figures (2, 3& 4). The results show the expected trend of increasing in conductivity with increasing in Al waste weight fraction . when the material is placed in an electric field as shown in fig. (1) the electrical resistance decrease with increase the waste-Al concentration because when electric current move through the matrix material a conductive network is formed and this permits the movement of charge carries of the particle through the matrix. As a concentration of waste -Al increase the number of conductive paths increase and the distance between the conductive fillers becomes smaller so the resistance of the composite decrease [7] and depending on equation(1) the electrical conductivity of material increase with decrease in material resistance so the electrical conductivity increase with increase fillers concentration.

Electrical conductivity behavior of waste -Al reinforced polyester composite material in different solutions (distilled water, tap water & water +3.5%NaCl) with a weight fraction (5, 15, 30 &45) for 6 week immersion time as shown in figures (2-4) and in tables (1-3), The results exhibit that electrical conductivity increases as increasing immersion time due to the specimen was absorbed the solutions then the values will be constant because of the specimen was saturated with solution and swelling.

The electrical conductivity values were different from solution to another according to ions in aqueous solution, therefore the maximum value was recorded at 3.5% NaCl solution, it reached (13.44 $*10^{-8}$ S/cm) with (45% Al) for 6 week.

If water has even a tiny amount of such an impurity and when the material is placed in an electric field as shown in fig. (1) the impurities such as salt separate into free ions in aqueous solution by which an electric current can flow and because the charge is carried by ions or electrons then when the concentration of impurity increase this mean the electrical charges carriers (ions) is increased and the conductivity of electrical is increases.

Conclusion

1- The results exhibited that increasing in electrical conductivity with increasing in immersion time.

2- Electrical conductivity increases with increasing in weight fraction of waste aluminum.

3- Maximum value of electrical conductivity was recorded at immersion in water +3.5% NaCl solution.

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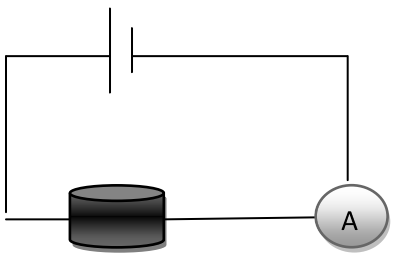

Figure (1): schematic diagram of measurement apparatus

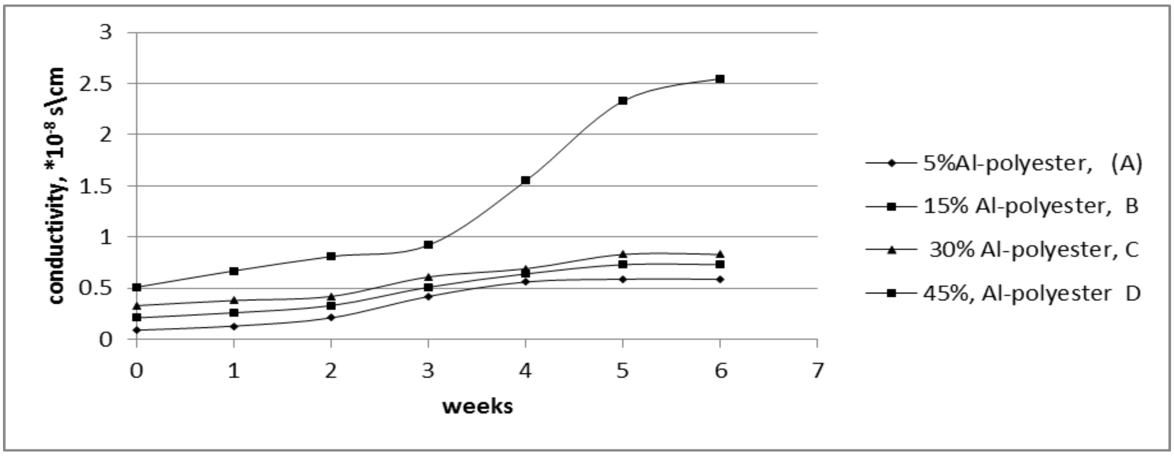

Figure (2): the variation of electrical conductivity (σ) with immersed in distilled water

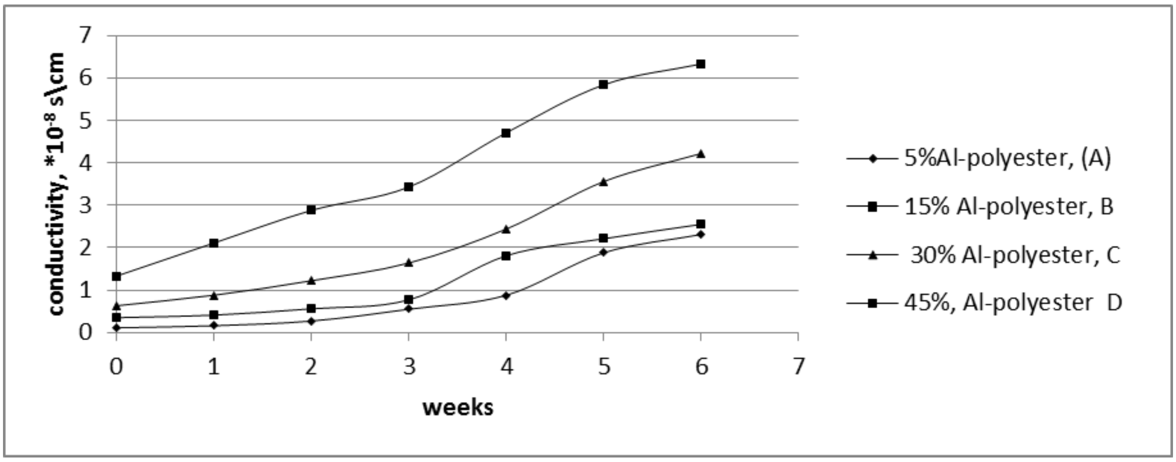

Figure (3): The variation of electrical conductivity (σ) with immersed in tap water

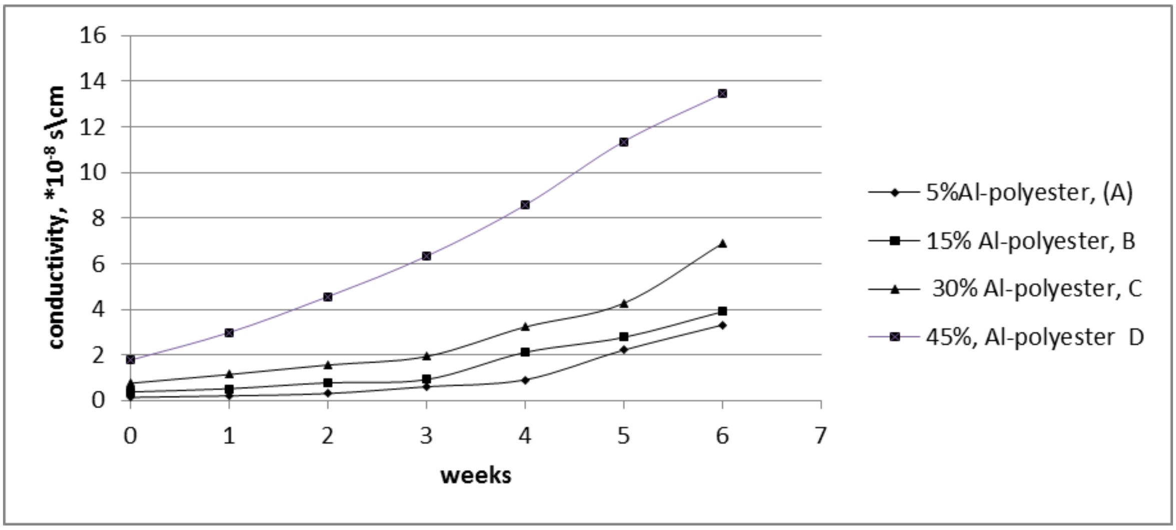

Figure (4): the variation of electrical conductivity (σ) with immersed in (3.5% NaCl)

Table (1): The variation of electrical conductivity (σ) with immersed in distilled water

Samples	$\sigma * 10^{-8}$ S\cm						
	0 Week	1 week	2 week	3 week	4 week	5 week	6 week
5%Al-polyester, (A)	0.09	0.13	0.21	0.42	0.561	0.588	0.588
15% Al-polyester, B	0.21	0.26	0.33	0.51	0.64	0.73	0.73
30% Al-polyester, C	0.33	0.38	0.42	0.61	0.69	0.83	0.83
45%, Al-polyester D	0.51	0.67	0.81	0.92	1.55	2.33	2.55

Table (2): The variation of electrical conductivity (σ) with immersed in tap water

SampleS	$\sigma * 10^{-8}$ S\cm						
	0 Week	1 week	2 week	3 week	4 week	5 week	6 week
5%Al-polyester, (A)	0.11	0.16	0.27	0.55	0.88	1.88	2.31
*15% Al-polyester, B	0.35	0.41	0.56	0.77	1.81	2.21	2.55
30% Al-polyester, C	0.63	0.88	1.22	1.64	2.44	3.56	4.22
45%, Al-polyester D	1.33	2.11	2.88	3.43	4.71	5.84	6.33

Table (3): The variation of electrical conductivity (σ) with immersed in (3.5% NaCl)

Samples	$\sigma * 10^{-8}$ S\cm						
	0 Week	1 week	2 week	3 week	4 week	5 week	6 week
5%Al-polyester, (A)	0.14	0.21	0.31	0.61	0.91	2.21	3.31
15% Al-polyester, B	0.38	0.52	0.78	0.92	2.11	2.77	3.89
30% Al-polyester, C	0.76	1.14	1.56	1.93	3.22	4.26	6.88
45%, Al-polyester D	1.77	2.98	4.55	6.32	8.56	11.35	13.44

تأثير محاليل مائية مختلفة على التوصيلية الكهربائية للبولي استر المدعم بقطع الالمنيوم التالفة

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الخلاصة:

في هذا البحث تم دراسة تأثير محاليل مختلفة (ماء مقطر, ماء الحنفية و ماء +3.5 % كلوريد الصوديوم) على سلوك التوصيلية الكهربائية للمواد المتراكبة من البولي استر المدعم بقطع من الالمنيوم التالف بنسب وزنية ((5, 15, 30 &45) % خلال 6 اسابيع. اظهرت النتائج ان التوصيلية الكهربائية تزداد بزيادة فترة الغمر, كذلك وصلت اعلى قيم للتوصيلية عند الغمر بمحلول كلوريد الصوديوم. التوصيلية الكهربائية تزداد بزيادة النسب الوزنية للألمنيوم وذلك بسبب مسارات انتقال الالكترونات اصبحت مفتوحة اكثر.